SECTION 1: STUDY OBJECTIVES

The goal of this study is to develop a research plan to test live-capture gear for summer/fall Chinook salmon broodstock collection in the Okanogan, Similkameen, and Columbia rivers.

The summer/fall Chinook salmon broodstock for the current Eastbank Hatchery program are descendants from stock manipulations carried out during the Grand Coulee Fish Maintenance Program and mitigation for mainstem Columbia River dams, resulting in a homogenized population (Talayco 2002). Moreover, propagation probably incorporated fall-run fish into the summer Chinook salmon population. The upper Columbia River summer/fall Chinook salmon ESU includes the Methow, Wenatchee, Columbia, and Okanogan basins. The Colville Tribes would like to produce a summer/fall Chinook salmon population locally adapted to the Okanogan River, which will ultimately be self-sustaining and harvestable.

SECTION 2: STUDY AREA

The study area includes mainstem reaches of the Columbia River between the Okanogan River confluence and Chief Joseph Dam (RM 533, Rkm 858), the Okanogan River below Osoyoos Lake (RM 77.4, Rkm 125), and the Similkameen River below Enloe Dam (RM 6.6, Rkm 10.6).

SECTION 3: METHODS

In this section of the report we describe the methods used to develop the broodstock collection study plan.

3.1 Literature Review

A literature review was conducted to compile data on potential techniques for selective live capture of fish and on physical conditions of the Okanogan basin. In addition, studies and documents were reviewed to provide background information for describing the study area and for determining stream temperature and flows, run-timing for summer/fall Chinook salmon and other species, and the presence of species protected under the Endangered Species Act (ESA) that may be impacted by the broodstock collection program.

3.1.1 Stream Temperature and Flow Data

The Colville Tribes have an extensive amount of temperature data at various locations in the Okanogan River and several of its tributaries. Temperature data for the Similkameen River and the Okanogan River at Malott, WA (~RM 17, Rkm 27) and at Oroville, WA (~RM 78, Rkm 125) were obtained for consideration in determining suitable times when broodstock could be collected and handled with minimal stress. In addition, the Columbia River DART system, operated by the University of Washington, was queried for data on Columbia River stream temperatures above Wells Dam.

Stream flow data for the Okanogan and Similkameen rivers were obtained from USGS gaging stations in these basins.

3.1.2 Summer/Fall Chinook Salmon Run Timing and Abundance

Washington Department of Fish and Wildlife (WDFW) was consulted on summer/fall Chinook salmon abundance, run timing, and locations of spawning aggregations within the Okanogan basin.

3.1.3 Permits

An inquiry was conducted to determine the presence of any ESA-listed fish potentially occurring within the study area. In addition to the potential need for a Section 10 permit for the unintentional take of ESA-listed fish, WDFW and Colville Tribes were contacted to determine if any state or tribal permits would also be required for broodstock collection.

3.2 Site Review and Selection

An initial site visit was conducted March 10 to March 12, 2004. The Columbia River and Okanogan River below Monse Bridge (~RM 5, Rkm 8) were surveyed via jet boat. Several sites along the remainder of the Okanogan River, Omak Creek, and the

Similkameen River were surveyed by vehicle and on foot. In addition to potential fishing areas, Bonaparte, Ellisforde, and Similkameen Pond acclimation facilities were visited. The purpose of these site visits was to identify suitable sites for fishing the different types of live-capture gear identified in the literature review. Also, physical conditions at each site were visually inspected to determine substrate type, presence of large woody debris, and access. Photographs of possible fishing sites were taken to document findings.

SECTION 4: RESULTS

4.1 Literature Review

The results of the literature review are presented below. As this review relied heavily on Internet searches of federal, state, tribal, and Canadian web sites, the web addresses for the majority of the documents reviewed are included in the References section of this report. In this section we describe the basin, identify summer/fall Chinook salmon geographic and temporal spawning distributions, describe ESA species in the area, and, most importantly, describe the different types of live-capture gear that may be used to collect anadromous salmonids on the west coast of the U.S. and Canada.

4.1.1 Okanogan Basin Description

The Okanogan River is the uppermost Columbia River tributary currently accessible to anadromous fish. It originates in British Columbia and flows south to its confluence with the Columbia River at RM 533.5 (Rkm 858). Within the U.S., the Okanogan River flows for approximately 79 miles with elevations ranging from 920 feet at the Canadian border to 780 feet at Lake Pateros (Talayco 2002). The overall stream gradient for this portion of the Okanogan River is 0.04 percent. River substrate is typically silt, sand, gravel, and cobble, which were deposited in the valley during the last period of large-scale glaciation. Conversations with local biologists revealed that the stream channel is relatively free of obstructions, snags and large woody debris—this was confirmed during the field visit.

The Okanogan River is a shallow, low gradient, relatively homogenous system. Its steep valley walls and loose soil, composed of volcanic ash and glacial deposits, contribute to high sediment delivery.

Hot dry summers and cold snowy winters characterize the Okanogan River basin. Average precipitation in the main river valley is 12 inches, the majority of which falls as snow (Talayco 2002). The Okanogan basin is a typical snowmelt system in which high flows coincide with spring rains and melting snow pack (Fig. 1), peaking between late May and early June. Minimum flows occur in early fall to mid-winter. The Similkameen River comprises 75 percent of the total Okanogan River flow (Talayco 2002) (Figs. 1 and 2). Isolated summer thunderstorms, occurring approximately once every two years, can cause flash flooding within a sub-watershed.

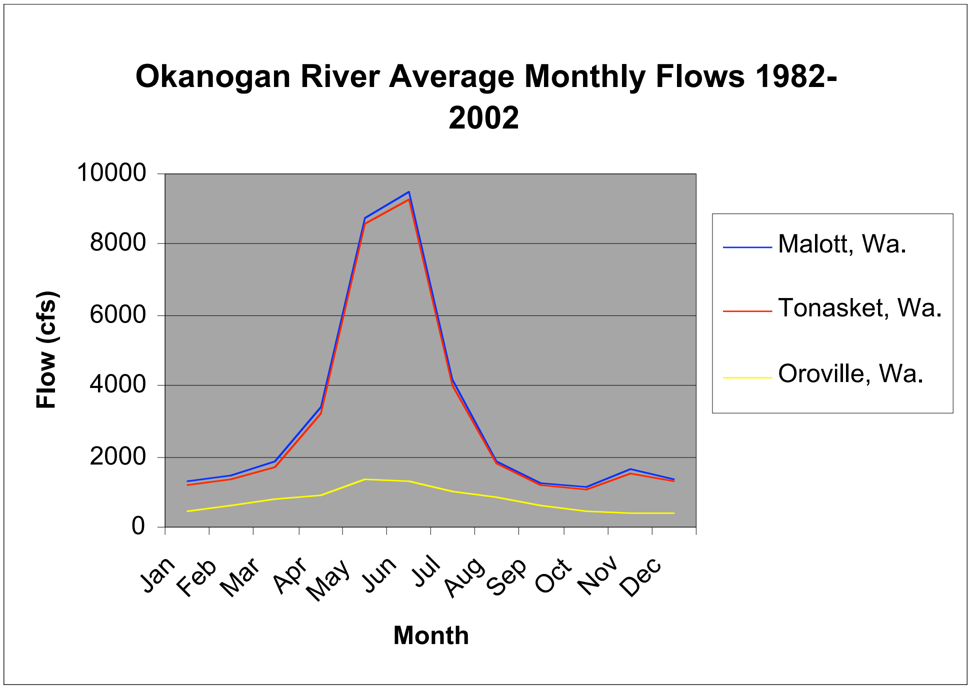

Figure 1. Okanogan River average monthly flows measured at USGS gaging stations 1982-2002 at Malott, Tonasket and Oroville, WA.

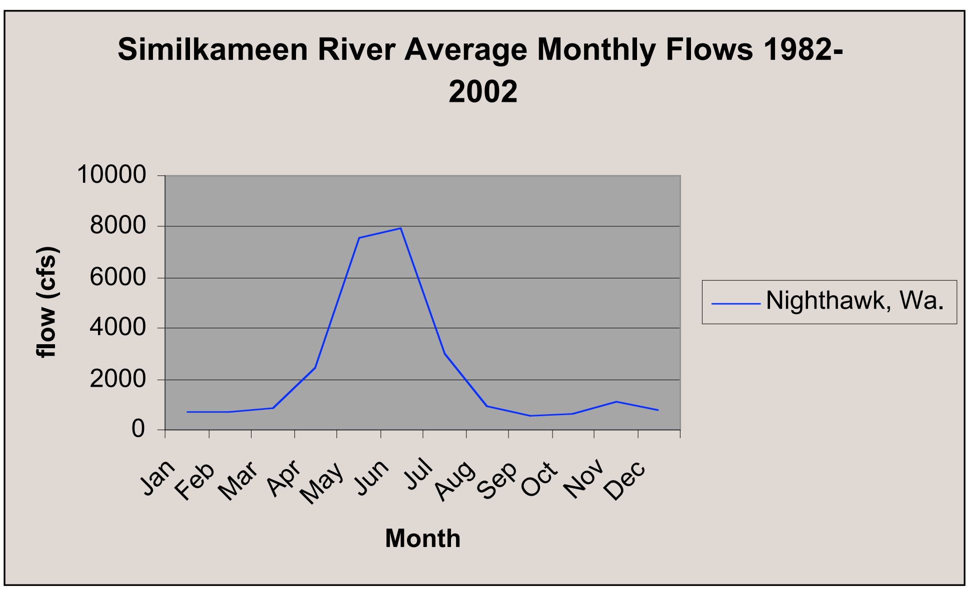

Figure 2. Similkameen River average monthly flows measured at USGS gaging station 1982-2002 at Nighthawk, WA.

The Okanogan River is 303(d) listed for failure to meet water quality standards for temperature, pH, and fecal coliform (Talayco 2002). Temperature and flow have been identified as the most significant problems for salmon recovery in the Okanogan watershed.

Okanogan River temperatures regularly exceed lethal tolerance levels for salmonids in mid-to-late summer. Temperatures in the Okanogan River ranged from 32 °F to 85 °F between 1998 and 2001 (Colville Tribes, unpublished data). Due to the extensive series of lakes in the Canadian portion of the basin, the Okanogan River is warmer near Oroville, WA, than it is at Malott, WA (Figs. 3 and 4). High water temperatures in late summer and fall often form a thermal barrier, blocking adults from migrating to spawning grounds. The thermal barrier has also excluded juvenile salmon from rearing in most of the Okanogan basin, except during the first few weeks after emergence (Talayco 2002). When temperatures reach critical levels, dissolved oxygen concentrations in the Okanogan River are generally at or above saturation levels. The lowest saturation values have been detected at Malott, WA.

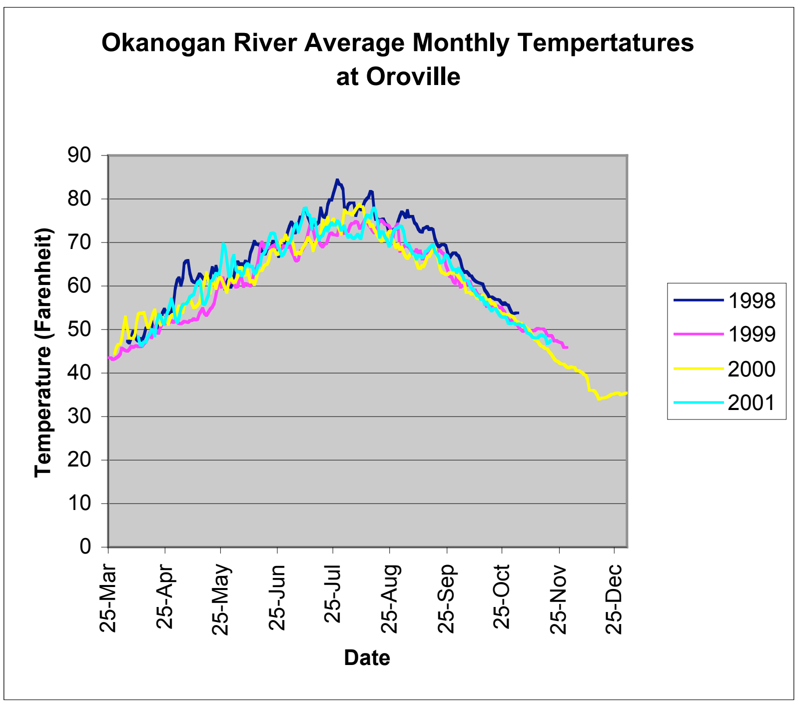

Figure 3. Okanogan River average monthly temperatures measured at Oroville, WA with thermographs 1998-2001.

Although it is typically cooler than the Okanogan River, the Similkameen River is also 303(d) listed for temperature (see Fig. 5). Between 1999 and 2001, Similkameen River temperatures ranged from 33 °F to 74 °F (Colville Tribes, unpublished data). Mid-summer temperatures exceed 71 °F, precluding summer rearing of salmonid juveniles. The Similkameen River also has high levels of suspended sediment.

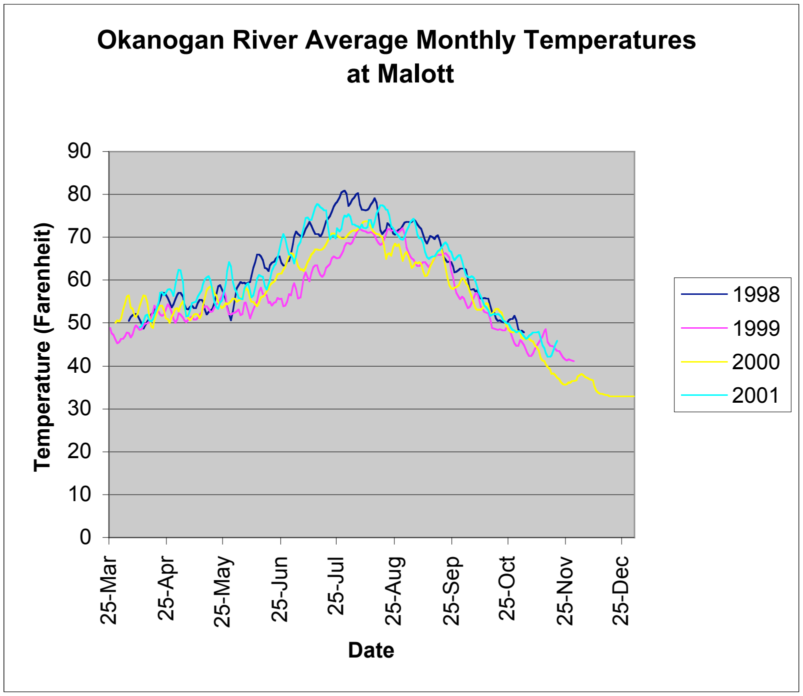

Figure 4. Okanogan River average monthly temperatures measured at Malott, WA with thermographs 1998-2001.

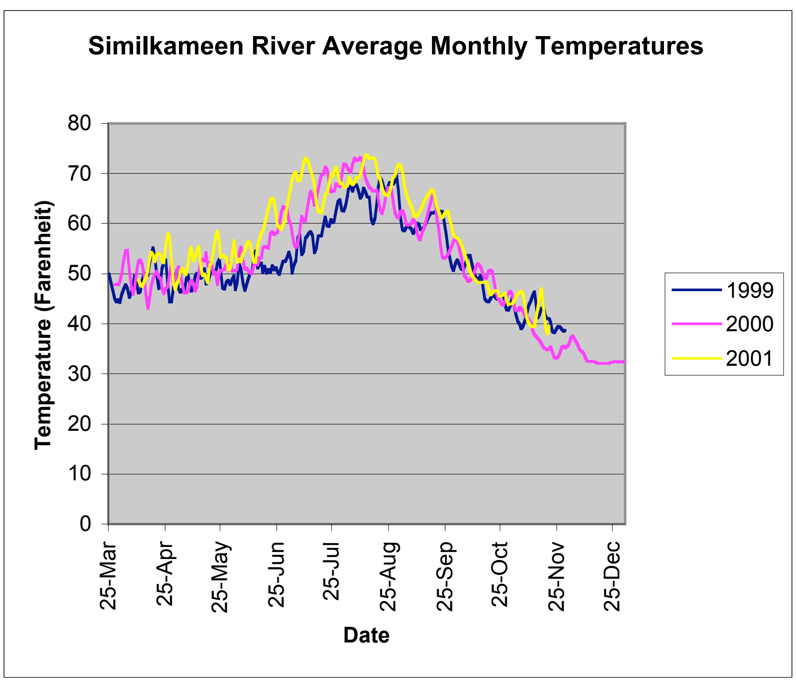

Figure 5. Similkameen River average monthly temperatures measured with thermographs 1999-2001.

The first 17 miles of the Okanogan River lie within the backwater pool (Lake Pateros) of Wells Dam. This area is subject to daily water fluctuations from Wells Dam operational changes. The habitat is primarily lentic with a mud, silt, and sand substrate. Large woody debris is scarce. Temperatures in this portion of the Columbia River range from 38 °F to 75 °F.

Pools and woody debris are uncommon in the remainder of the Okanogan River below Osoyoos Lake. The substrate is typically cobble/gravel with high amounts of fine sediment; embeddedness is also widespread. The Okanogan River is subject to elevated levels of suspended sediment during high spring flows and rain events (Talayco 2002).

4.1.2 Summer/Fall Chinook Salmon Geographic and Temporal Spawning Distribution

Summer/fall Chinook salmon adults return to Wells Dam beginning in late July. Spawning occurs from late-September through mid-November, peaking early- to mid-October. In late summer, temperatures in Lake Pateros are cooler than those in the Okanogan River. Fish congregate along the west bank of Lake Pateros, downstream of the Okanogan River confluence (pers. comm., C. Fisher, Colville Tribes). Adults migrate into the Okanogan River when temperatures cool due to rain events or seasonal changes. Summer/fall Chinook salmon that return to the Okanogan basin display a temporal spawning pattern in which spawning begins in the upper reaches first and proceeds to the lower river reaches. It is hypothesized that the early returning adults migrate up the Similkameen River in early September and hold in the pools (pers. comm., M. Tonseth, WDFW). At this time of year, the Similkameen River has the coldest water in the Okanogan basin. Some of these fish spawn in the Similkameen River beginning the last week of September. A portion of these fish may hold in the Similkameen River below the Enloe Dam falls and migrate back downstream and disperse into the upper Okanogan River as the temperatures cool, where they spawn in mid- to late-October. Later returning adults congregate in Lake Pateros and move into the Okanogan River as temperatures cool, populating the spawning reaches in the lower portion of the Okanogan River.

Spawning activity begins late-September to early-October in the Okanogan River upper basin. Below RM 40.6 (Rkm 65.4), spawning generally begins mid- to late-October. Spawning occurs in spatially discontinuous areas of the Okanogan River between Malott, WA, and Zosel Dam. The majority of spawning in the Okanogan occurs (1) between the towns of Okanogan and Omak (RM 25to RM 31, Rkm 40to Rkm 49), (2) below McAllister rapids (RM 45, Rkm 72), (3) between Janis Bridge (HWY 97/20) and Tonasket (RM 53 to RM 57, Rkm 85 to Rkm 92), and (4) between the Horseshoe Lake area and Oroville (RM 70 to RM 77.4, Rkm 113 to Rkm 124.5) (pers. comm., M. Tonseth, WDFW). Of these areas, the latter two have the highest concentrations, accounting for 68-86.2 percent of the Okanogan River redds observed in 2001-2003. Annual summer/fall Chinook salmon escapement ranged from 2,505 to 6,134 fish between 2001 and 2003 (Miller 2004a, Miller 2004b, Miller 2004c). Of the carcasses sampled over the same time period, marked hatchery-origin fish accounted for 36.2 to 61.4 percent, with percentages increasing with increased total escapement.

In the Similkameen River, spawning occurs in the lower miles from the mouth to Enloe Dam. About 80 percent of the documented redds are concentrated below the Oroville Bridge, primarily in a 1.8 km reach near Similkameen Pond (pers. comm., M. Tonseth, WDFW). Redd superimposition is common in this area; in 2002, the summer/fall Chinook salmon redd concentration was 1,397 redds/km (Miller 2004b). Marked hatchery-origin fish comprised 49 to 70.3 percent of the natural spawners between 2001 and 2003 (Miller 2004a, Miller 2004b, Miller 2004c).

In addition to the documented spawning escapement in the Okanogan and Similkameen rivers, the Colville Tribes harvest summer/fall Chinook salmon using gillnets in the Okanogan River and hook and line in Lake Pateros. Between 1987 and 1992, the average annual harvest was 800 adults, primarily taken at the base of Chief Joseph Dam (Talayco 2002).

4.1.3 ESA-Listed Species

NOAA, under the Endangered Species Act, listed Upper Columbia River (UCR) steelhead trout as endangered on August 18, 1997 (Talayco 2002). The listed Ecologically Significant Unit (ESU) includes naturally spawning steelhead trout populations in the Columbia River basin and its tributaries from the Yakima River upstream to the Canadian border and the Wells Hatchery stock. The Okanogan basin and the Columbia River below Chief Joseph Dam were designated as critical habitat (Talayco 2002). A small summer run of steelhead trout occurs in the Okanogan River basin, primarily spawning in Omak Creek. Summer/fall Chinook salmon broodstock collection efforts may adversely affect UCR steelhead. Consequently, a Section 10 incidental take permit will most likely be required prior to any broodstock collection efforts.

The Upper Columbia River ESU spring Chinook salmon population was listed as endangered on March 24, 1999 (Talayco 2002). The listed ESU includes naturally spawned populations of spring Chinook salmon occurring in the Columbia basin and its tributaries, between Rock Island Dam and Chief Joseph Dam, <u>excluding</u> the Okanogan River. The Methow River spring Chinook salmon hatchery stock is also included within the listed ESU. Spring Chinook salmon are considered extirpated from the Okanogan River (Talayco 2002).

4.1.4 Potential Selective Fishing Gear

Based on the variable stream and environmental conditions present in the Okanogan, Similkameen, and Columbia rivers, it is expected that a range of live-capture gear and methodologies would have to be tested to determine which is the most effective at collecting broodstock in different locations. Therefore, the strategy for broodstock collection will include multiple fishing sites with various gear types.

4.1.4.1 Tangle Net

A tangle net consists of one or more panels of webbing, vertically oriented in the water column by a cork line attached at the top and a lead line attached at the bottom. Tangle nets consist of multi-strand webbing with mesh sized to capture fish by the maxillary and teeth (e.g., typically 3.5-in to 4.5-in mesh for Chinook salmon), allowing fish to respire while caught in the net. They differ from gillnets, which typically consist of single-strand monofilament webbing with mesh sized to capture fish by the gill plates or body (e.g., typically 8-in mesh for Chinook salmon). Due to the manner in which fish are caught, use of tangle nets results in less mortality than gillnets. Fish captured in gillnets have higher mortalities due to extensive tissue damage and bleeding, or constriction of the gill plates that leads to death through suffocation. Tangle nets and gillnets are fished in the same manner.

Tangle nets vary in mesh size, twine diameter, panel length, and depth. The 3.5-in mesh has been found to be the most effective in capturing salmonids (Petrunia 2000). Tangle net evaluations conducted on the Columbia River have found 3.5-in and 4.5-in mesh nets of varying lengths and depths to be effective in capturing Chinook salmon. The number of fish caught and net mortality rates decrease as mesh size decreases and catch efficiency decreases with increasing twine thickness (Petrunia 2000). Webbing may also vary in color. Tangle nets are not effective if the fish are able to see the net. If fished at night or in turbid conditions, color has not been found to affect catch efficiency.

Nets can be designed with different hang ratios. Hang ratio is defined as the ratio between the length of the webbing versus the length of the cork line (Vander Haegen et al. 2002). Tangle nets have been fished at 3:1 and 2:1 hang ratios with varying catch efficiencies and mortality.

Tangle nets can be set or allowed to drift at different depths in the water column. The most effective method for capturing salmonids is the use of a diver net allowed to drift along the bottom.

Nets may also be modified to fish portions of the water column, thus targeting certain species and reducing incidental bycatch. During Fraser River gillnet investigations, steelhead trout were captured in the upper portion of net, while Chinook salmon were predominantly caught in the lower half of the net (Thomas 1998a, Kadyschuk 2000, Department of Fisheries and Oceans Canada (no date)). Other studies have also found steelhead trout to prefer the upper water column (Quinn and Ruggerone 1988, LaBelle 1995). On the Skeena River, gillnets were modified such that the panel of webbing was at the bottom of the water column and vertical weedlines extended from the panel to the cork line at the surface. Use of weedlines reduced the steelhead trout catch (LaBelle 1995).

In deep-water sites, nets can be deployed and retrieved by hand or by a deck-mounted hydraulic reel in an open skiff. Set duration is longer if deploying and retrieving the nets by hand. Shorter soak periods have resulted in better fish condition upon capture and reduced mortality. Nets can be deployed within five minutes with the use of a hydraulic reel. After deployment, the net is monitored for movement indicative of fish capture. The net should be patrolled to maintain a short soak time and clear any debris.

Figures 6 and 7 depict fishermen retrieving and deploying gillnets from a boat.

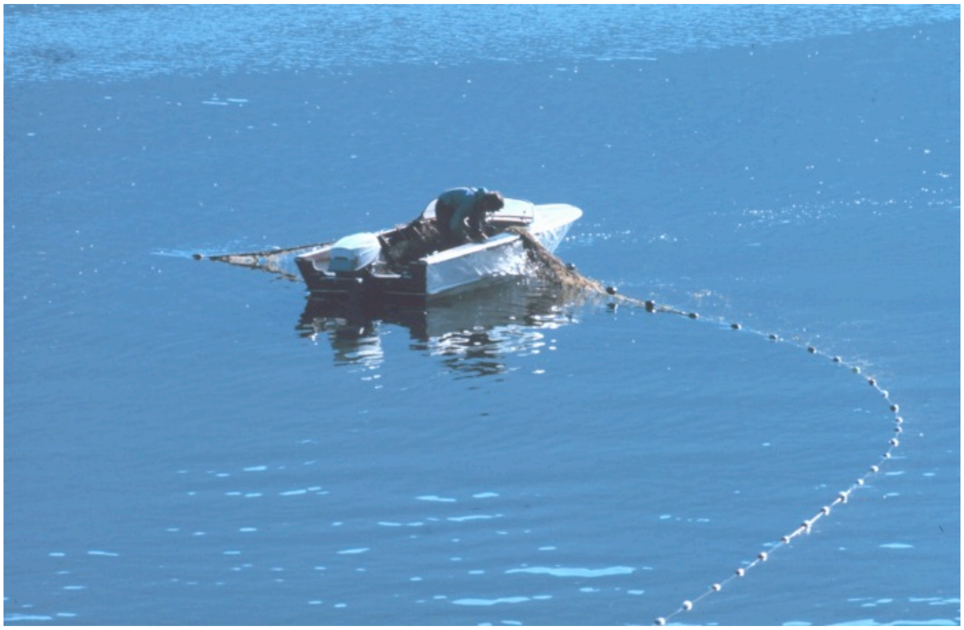

Figure 6. A Native American gillnet fishing in the Columbia River (Photolib.noaa.gov).

Figure 7. Fisherman setting a gillnet near Darango State Park, Washington, Rocky Reach Dam Reservoir (Streamnet.org).

<u>Site criteria for tangle nets</u>:

- Tangle nets can be used in shallow or deep water and in weak to fast-moving currents.

Advantages of tangle nets:

- It is easier to safely remove fish from tangle nets than gillnets.
- Tangle nets have been found to be effective in capturing spring Chinook salmon on the Columbia River and sockeye and spring Chinook salmon on the Skeena River (Vander Haegen et al. 2002).
- In a study conducted at Budd Inlet in 2000, immediate mortality of adult fall Chinook salmon was found to be significantly less in tangle nets (21.4%) than gillnets (40.2%) (Vander Haegen et al. 2004). Of this mortality, 22 percent was attributed to seals. However, the following year, when retrieval times were extended due to use of the hand deployment/retrieval method and warmer water temperatures (15 °C to 20 °C), immediate mortality rates for gillnets and tangle nets were found to be 19.1 and 32.0 percent, respectively, with no statistically significant difference between gear types (14% of the total mortality in 2001 was attributed to seals). In a lower Columbia River evaluation, 536 spring Chinook salmon were captured in tangle nets, with immediate mortality rates of 4.3 percent (3.5-in mesh) and 2.6 percent (4.5-in mesh) (Vander Haegen et al. 2002).
- At various locations, adult fall Chinook salmon captured in tangle nets have been found to be in better condition than those caught in gillnets and have exhibited higher post-release survival (Vander Haegen et al. 2004). Higher mortality rates were also observed for all species caught in gillnets at a Willapa Bay study site. Tangle-net caught fish had net marks around the lower snout and jaw while many gillnet-caught Chinook salmon were bleeding at capture and had net marks around the body and gills. The gillnet-caused marks were severe; scales were dislodged and missing, leaving the underlying skin abraded and red. It is likely that secondary fungal infections subsequently occurred.
- Lower Columbia River tangle net evaluations revealed that, of the 43 steelhead trout captured, all were released in excellent condition (Vander Haegen et al. 2002). Sturgeon were also released in good condition.
- In the lower Columbia River, tangle net-captured spring Chinook salmon exhibited higher long-term post-release survival than those captured in gillnets. Spring Chinook salmon released from tangle nets were recovered at 80.9% - 92% of the rate of controls, while gillnet-captured spring Chinook salmon were only recovered at 50% of the rate of controls (Vander Haegen et al. 2002).
- Fish harvested from tangle nets have fewer net marks and may yield a higher market value.
- The relatively smaller tangle net mesh used to target salmon, allows for a wider size range of the target species to be caught (Vander Haegen et al. 2004), minimizing the potential for artificially selecting larger fish for broodstock or harvest and leaving smaller fish for natural production.

Disadvantages of tangle nets:

- Long-term post-release mortality may be significant. In tangle net studies conducted on the lower Columbia River, approximately 20 percent of spring Chinook salmon released from tangle nets were not subsequently recovered (Vander Haegen et al. 2002).
- Evaluations of tangle nets in Budd Inlet revealed a lower catch efficiency of fall Chinook salmon in tangle nets (3.5-in and 4.5-in mesh) than in gillnets (8-in mesh) (Vander Haegen et al. 2004). On the Skeena River, the number of fish captured and catch per unit effort (CPUE) were found to be greater for most salmon species when using a monofilament net versus a multistrand net (DFO 1990). However, lower Columbia River evaluations revealed 4.5-in mesh tangle net to be as effective as 8-in mesh gillnet in capturing spring Chinook salmon (Vander Haegen et al. 2002). Multifilament nets have also been found to catch more steelhead trout than monofilament nets (Lewynsky 1992).
- Tangle nets have a higher catch of non-target species and jacks than gillnets due to smaller mesh size (Vander Haegen et al. 2004). In addition to potential impacts to the non-target species, their increased catch results in extending the duration of net retrieval and the period of time that all fish remain in the net. In lower Columbia River tangle net evaluations, sets with dead adult spring Chinook salmon had significantly higher numbers of non-salmonids (Vander Haegen et al. 2002). Reduced CPUE for the targeted species is another consequence of increased bycatch.
- Salmonids captured in tangle nets may also be skewed towards males. In tangle net evaluations conducted on the Columbia River, 75.7 percent of the captured fish were males (Vander Haegen et al. 2004). The difference was attributed to the kype, which is more susceptible to capture in a tangle net.
- Fish captured in good condition and able to be released upon capture exhibited the greatest long-term post-release survival. Captured fish that required revival in recovery boxes and were released upon visual inspection may not have been fully recovered physiologically and may require a longer holding period (Vander Haegen et al. 2002).

4.1.4.2 Beach Seine

Beach seines have been successfully used in selective harvest by First Nations on the Skeena and Fraser Rivers (pers. comm., Don Lawseth, Department of Fisheries and Oceans, Canada.)

A beach seine consists of a panel of mesh webbing with a float line at the top and a lead line at the bottom. Beach seines can vary in length, depth, amount of bag, mesh size, and twine composition and diameter. The middle portion of the net, called the “bunt,” may have a larger bag and a smaller mesh than the rest of the net (Everhart and Youngs 1981). The configuration of a beach seine is dictated by the fishing site (Ross 1998). Gear efficiency and feasibility is site specific. The depth of the nets may be uniform or they may taper at either end, closely corresponding to the depth of water in fish holding areas.

The depth should be sufficient enough to allow for sweeping the entire water column while maintaining a bag in the net. Net depths twice the depth of the water column have been found to be effective (Bayley and Herendeen 2000).

There are also trade-offs in seine lengths. Longer seines result in reduced gear avoidance behavior (Bayley and Herendeen 2000). However, capture efficiency is influenced by fish density, abundance of woody debris and rooted vegetation, habitat type, substrate type and homogeneity, and water clarity. Use of a shorter seine minimizes the reduced capture efficiency associated with varying water depth, substrate, and woody debris. The weight of the lead line must be suited to the flow conditions (Ross 1998). Monofilament web is more effective in streams with clear water (Ross 1998).

Capture efficiency also varies with the fishers' skills to encircle the fish as the net is laid and retain the fish as the net is hauled (Bayley and Herendeen 2000). Precautionary techniques can be implemented to increase catch efficiencies. It is important to close the ends of the net, secure the lead line at the bottom, and clear any woody debris or boulders from within the enclosure prior to hauling. Nets may also be modified to ensure successful capture of the encircled fish. Attaching rings to the net allows it to be completely closed up prior to retrieval. By using a block net in conjunction with the beach seine, the catch efficiency can be maximized.

Beach seines may be deployed on foot or from a quiet boat or raft. Figures 8 and 9 depict people hauling in a large beach seine and retaining the encircled fish, respectively.

Figure 8. Fishermen hauling in a large beach seine that was set using a boat (www-sci.pac.dfo-mpo-gc.ca).

Figure 9. Fishermen retaining encircled fish by holding up the cork line (fisheries management.co.uk).

<u>Site criteria for beach seines</u>:

- Beach seines are most effective in shallow slow-moving water, free of woody debris, and where fish occur in high densities. Beach seines would be effective on the spawning grounds or in hyporheic areas where fish may congregate and hold.

<u>Advantages of beach seines</u>:

- Beach seines provide for live sort of the catch and can be a useful tool for stock assessment.
- In studies investigating beach seine feasibility for selective fishing, most fish appeared to be in excellent shape and were released without the use of a resuscitation tank or required very little recovery time (Thomas 1998). When used on the Fraser River to capture coho and chum, only one mortality was observed, which seemed to be caused by a previous seal attack. At Shuswap River sites, none of the captured fish required additional holding in net pens to resuscitate before release (Ross 1998).

<u>Disadvantages of beach seines</u>:

- Beach seines are not suitable for high water velocities (Triton Environmental Consultants Ltd 1998c).
- The presence of woody debris (logs, stumps, snags) delays net retrieval, reducing capture efficiency and potentially tearing the seine (Thomas 1998b). The fishing site could be prepared by the removal of woody debris, rooted vegetation, or large boulders. However, habitat of the fishing site may potentially be degraded by such actions.

- Post-release stress-related mortalities potentially occur from seining and handling. In some cases, captured fish seemed to be stressed and somewhat sluggish, but little if any physical trauma was observed (Thomas 1997). However, a recovery area (e.g., net pen, tank with recirculating water system) was necessary to hold lethargic fish prior to release.
- Capture efficiency varies between sites, species, and fishers. Beach seines were found to be ineffective in capturing late summer sockeye at various sites in the Shuswap River (Ross 1998).

4.1.4.3 Floating Trap-Net

Floating trap-nets are designed to lead fish into an enclosure from which they are unable to escape. Configurations can vary widely and include traps such as fyke nets, floating pound nets, and Merwin traps.

A fyke net consists of a long mesh bag mounted on several hoops attached to vertical net wings set at angles on either side of the opening (Everhart and Youngs 1981). The wings funnel fish toward the mouth of the net as they swim with the current. The hoops maintain the shape of the bag. Net funnels are attached to the hoops to prevent fish from escaping. Each wing panel has a lead line at the bottom to weight it down and a cork line to maintain its vertical orientation in the water column. The length of the wings and bag may vary. Shorter wings and long bags are used in swift currents. Where water velocities are slow, longer wings may be used. The fyke net may be set with anchors or stakes, depending on flow conditions and net configuration.

Floating pound nets are effective in catching salmonids (Everhart and Youngs 1981). A vertical lead net is attached at one end to the shoreline. The other end has a funnel, which leads to the top of the “heart,” which is a three- to five-meter wide opening, lacking a bottom net. Traps used in tidal areas typically have openings into the heart from both sides of the lead. The heart is preceded by a tunnel leading to the four-meter square “pot.” The narrow mouth of the tunnel is typically 46–76 cm wide. From the pot, captured fish are lead through another tunnel, with a 15- to 30-cm adjustable opening, into the “spiller,” which is positioned alongside the pot. Two spillers may be attached to prevent overcrowding.

The entire floating pound net structure may be suspended from a rigid floating framework that is anchored into position. If fishing in very deep water, a rigid framework is impractical. In this case, top webbing is added to the trap and the shape is maintained with buoys and anchors. The latter design also facilitates moving the pound net to various sites as fish distribution changes (Everhart and Youngs 1981).

To empty the pound net, the spiller, which is held down by ropes, is lifted by hand or with the use of a winch. The web is hauled into a boat located inside the spiller. The catch is crowded and brailed or dipped out of the bag and into the boat.

The minimum size of fish caught is dictated by mesh size. The maximum size of captured fish is limited by the tunnel openings. In studies evaluating mesh and throat sizes for capturing warm water species, nets with large mesh and throat size had the highest CPUE

(Shoup et al. 2003). Trap net design was found to impact the number of species captured, total CPUE, species-specific CPUE, and length distribution of catch (Shoup et al. 2003).

Figures 10 and 11 depict different types of floating trap-net gear.

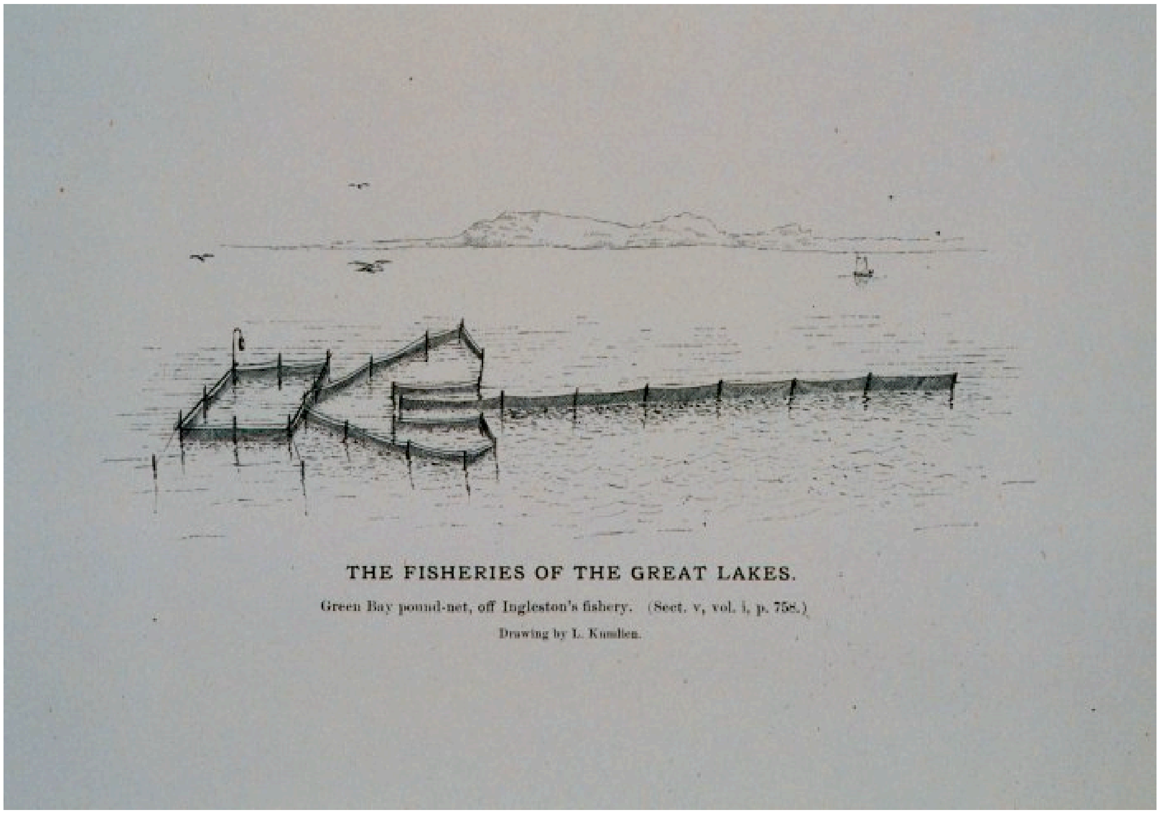

Figure 10. Schematic of pound net (streamnet.org).

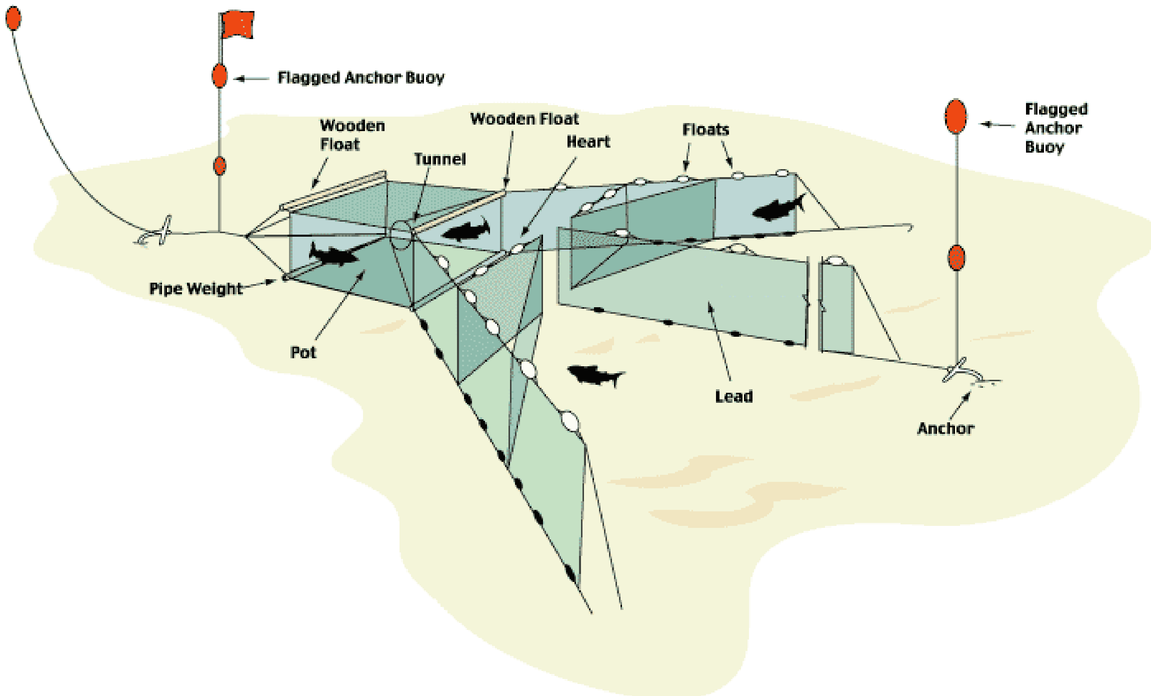

Figure 11. Trap-net design.

<u>Site criteria for trap-nets</u>:

- Floating traps can be fished in a variety of conditions ranging from shallow, fast-moving water to deep water with weak currents (Vander Haegen et al. 2002). Fyke nets are best adapted for relatively shallow water (<15 feet) with a moderate current (Everhart and Youngs 1981). Floating pound nets may be fished in deep water, at a range of water velocities.

<u>Advantages of trap-nets</u>:

- Fish captured in floating traps are typically in excellent condition and bycatch can be safely removed and immediately released, unharmed.
- Although it is best to minimize the amount of time fish are crowded and held in a trap, the floating traps described above do not need to be constantly manned by a full crew.

<u>Disadvantages of trap-nets</u>:

- Studies conducted in Canada have found floating traps to be marginally effective in capturing pink salmon, but ineffective in capturing other salmon species (Vander Haegen et al. 2002). Floating fish traps require the use of a boat, which can result in long holding and transport times.

4.1.4.4 Fish Wheel

A fish wheel consists of several baskets attached to an axle, about which they rotate. The trap is oriented parallel to the shoreline. In swift currents, the wheel is propelled by the flow of water. Fish are scooped up by the baskets and sent through a chute, from which they are deposited into a holding tank. The entire structure sits within a frame. Traps are typically fabricated from aluminum, but they have also been constructed from wood. A fish wheel may be used in conjunction with a ramp net lead system to increase catch efficiency.

Fish wheel designs vary widely. Figures 12 through 16 provide some examples. The Siska Indian Band has successfully used fish wheels to capture coho salmon in the Fraser River since 1998 (BC Aboriginal Fisheries Commission 2001). They use a three-basket aluminum fish wheel, approximately 40 feet long and 18 feet wide. Each basket is nine feet wide and eight feet deep, extending 8.6 feet from the axle. Foam-padded plywood is attached to the back of each basket to act as a paddle. Eight-inch knotless mesh covers the sides and back of the baskets. Fish wheels at other locations have added padding to the chute to reduce impact injury (Underwood et al. 2003). In a two-basket design used on the Yukon River to catch chum, the livebox was 2.4 meters long by 1 meter wide by 1.2 meter deep and was perforated with 5-cm holes, allowing water flow without tiring the fish (Underwood et al. 2003).

Figure 12. Kuskokwim fish wheel constructed from wood (watershed-watch.org).

Figure 13. Yale fish wheel (watershed-watch.org).

Figure 14. Two-basket fish wheel constructed of wood and styrofoam panels (taleblazing.com).

Figure 15. Two-basket aluminum fish wheel (home.att.net).

Figure 16. Three-basket fish wheel (Clarkejohn.com).

Yale First Nation found optimum speed to be one revolution every 20–25 seconds (Triton Environmental Consultants Ltd 1998, Yale First Nation Fisheries Stewardship Authority 2000).

Fish wheel traps require site-specific modifications to optimize efficiency. Reflection from aluminum traps and baskets have caused fish to shy away from the trap during the day. Spray-painting the frame black was found to improve day-fishing success (Manuck 2000). In some cases, fish escaped out the sides of the wheel between the dipping of each basket. Adding frames of knotless webbing along each side of each basket prevents fish from escaping in this manner and minimizes the potential for injury.

<u>Site criteria for fish wheels</u>:

- Suitable fish wheel sites are limited to areas with fairly constant water level and flows, within the pathway of migrating fish. If flows fluctuate during the fishing season, multiple alternate fishing sites are recommended (Triton Environmental Consultants Ltd 1998). Self-powered fish wheels must be placed in fast-moving current. However, powered fish wheels can be used in slower water currents.
- Fish wheels must be securely fastened to a mooring, bedrock bank, or other structure.

<u>Advantages of fish wheels</u>:

- Fish wheels have been successfully used by First Nations on the Nass, Skeena, and Fraser Rivers (pers. comm., Don Lawseth, Department of Fisheries and Oceans, Canada).
- Mortality rates are generally low. Fish wheels allow for the successful capture and safe release of both target and nontarget species (Triton Environmental Consultants Ltd 1998g and 1998j). Yale First Nation caught 26,026 salmon; less than three percent of these had injuries, nearly all of which were caused by seals and were not attributed to the fish wheel trap (Yale First Nation Fisheries Stewardship Authority 2000). Power-assisted fish wheels have also been found to be effective at capturing and releasing any species of salmon with no, only very minimal, stress (Manuck 2000). However, a recent evaluation of a fish wheel on the Yukon River showed that chum salmon trapped and released at one site were less likely to be captured at upstream sampling sites (Underwood et al. 2004).
- If strategically located in swift water, a self-propelled fish wheel captures and transfers fish into holding tanks with minimal human effort (BC Aboriginal Fisheries Commission 2001). The wheel may constantly fish 24 hours a day, with a crew of three checking the trap and handling fish in two three-hour intervals per day.

<u>Disadvantages of fish wheels</u>:

- Fish wheels must be located within the pathway of migrating fish. Fish wheels are a type of fixed gear, requiring strong anchoring points. In addition to limited site availability, it is generally impractical to break down a fish wheel and move it to an alternate site within a single fishing season.

- Fishing sites are limited to water levels and flows without extreme fluctuations. Spring freshets have been found to be hazardous to the fish wheel and operators. It is recommended to have multiple alternate fishing sites to accommodate changing flows throughout the fishing season, which can be impractical and costly (Triton Environmental Consultants Ltd 1998i).
- Fish wheels are custom made and are relatively expensive (~$50,000). In addition to initial fabrication expenses, subsequent modifications and construction of work platforms and handrails can be costly.
- There is potential for some fish mortality. Fish injuries may occur from vertical drops between the baskets and the holding tank, rubbing against the baskets or frame, or overcrowding.

4.1.4.5 Dip Net Combination with Partial Weir or Scaffold

A rock weir or log weir (Fig. 17) or temporary picket weir (Figs. 18 and 19) may be constructed to partially span the river, leading fish to migrate through a narrow area, from which they may be dip netted.

Figure 17. Log weir (Streamnet.org).

Figure 18. Nlaka'pamux picket weir located on the Nicola River (watershed-watch.org).

Figure 19. Picket weir leading fish through channel (dungevalley.co.uk).

In areas with cascading falls, fish are naturally concentrated in passable chutes. Temporary wood scaffolding or platforms may be constructed adjacent to these chutes, allowing access for dip netting. Figures 20 through 23 depict various platforms for dip net fisheries.

Figure 20. Klickitat Falls and Native American platforms for dip net fishery (streamnet.org).

Figure 21. Historical photo of Columbia River tribal dip net fishery (streamnet.org).

Figure 22. Historical photo of Columbia River tribal platform and dip net fishery (streamnet.org).

Figure 23. Dip netting for Chinook salmon (watershed-watch-org).

<u>Site criteria for dip-net combination with partial weir or scaffold</u>:

- Natural cascading falls are ideal areas for scaffolding. Narrow, confined reaches are better suited to construction of a partial weir. Both methods may not be appropriate in rivers with flashy flows and abundant large woody debris.

Advantages for dip-net combination with partial weir or scaffold:

- Minimal fish handling would be required. Incidental bycatch could be immediately placed back into the river upstream of the fishing site.
- This type of fishing gear is inexpensive and easily repaired.

Disadvantages for dip-net combination with partial weir or scaffold:

- Dip-netting may be labor intensive and the CPUE may be low. Depending on the dipping height, dip-netting fish may be physically demanding.
- Cascading falls are scarce in the Okanogan basin.
- Captured fish may be injured while thrashing in the net or accidentally falling out of the net onto rocks or the scaffold.
- Construction of a weir may require additional permits.

4.2 Site Review and Selection

Several sites were identified as potential fishing areas based on geomorphology, flow, temperature trends, fish distribution, run timing, and access. It should be noted that the sites selected are based on general information about the location of adult summer/fall Chinook salmon in key areas of the basin. In the future, radio-tag studies on adult summer/fall Chinook salmon captured and released at Wells Dam would be used to better define fish behavior, holding areas, and geographic distribution.

4.2.1 Wells Dam Pool (Lake Pateros)

The Okanogan River is warmer than the Columbia River, creating a thermal barrier to migrating summer/fall Chinook salmon adults. It is hypothesized that this thermal barrier causes Okanogan bound summer/fall Chinook to hold in this area until stream temperatures drop. If this assumption is correct, a capture facility at this location may provide an easily accessible location to collect a major portion of the summer/fall Chinook run. Consequently, an attempt at broodstock collection will initially occur in Lake Pateros. Two locations and types of fishing gear may be suitable in Lake Pateros.

4.2.1.1 Floating Trap-Net

A floating trap-net will be fished in the Columbia River below the Okanogan River confluence. Fish are known to congregate in Lake Pateros in the deep channel along the west bank, prior to migrating up into the Okanogan River (Fig. 24). A pound net design would work well; the water is relatively deep and the current is moderate. Wells Dam operations cause the flow of water in this area to change direction daily. Consequently, the configuration would be similar to nets used in tidal areas, where the fish can enter the heart on either side of the lead net. A lead line will be attached to the west bank directing the fish into the trap. This gear requires the use of a boat. At this site, water depth and boat ramp access are adequate to support the use of a boat throughout the fishing season.